Advances in Crop Science and Technology

ISSN: 2329-8863

Ejigu YG, Adv Crop Sci Tech 2021, 09:08

Research Article

Open Access

Assessment of the Adoption of Improved Tef (*Eragrostis tef*) Practices and factors impacting on Yield in Four Regions of Ethiopia

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Received date: August 02, 2021; **Accepted date:** August 16, 2021; **Published date:** August 23, 2021

Abstract

Tef is the main Ethiopian cereal crop cultivated over 3.02 million hectare of land, which is equivalent to 23.85% of the total area allocated to cereals in the country (CSA, 2018). It is a staple food for over 73 million Ethiopians providing good nutrition and gluten free for the consumers. Technology adoption is the only means to increase production and productivity of the crop. Therefore, this study aims to assess the adoption of improved tef practices impacting on yield and factors affecting the adoption of the practice in four regions of Ethiopia. Household survey and crop cut survey were used. Four districts, 101 each in Amhara, SNNP Tigray and 100 farmers in Oromia regions of Ethiopia were assessed in the study. Therefore, a total of 403 respondent farmers, were used. Data were analysed using SSPS. Among the seven improved practices assessed, fertilizer application, variety selection and use, land preparation and herbicide application showed higher adoption among the farmers. The correlation analysis results revealed that yield is positively and significantly correlated with land preparation (r=0.492), row planting (r=0.351) hand weeding (0.306), fertilizer application (r=0.143).This implies that the adoptions of these improved practices were contributing to yield increment. The result clearly indicated that the adoption of improved practices was influenced by a composite of demographic, socio economic and institutional factors. Partial budget analysis was employed using previous variable cost data collected in Ada district by Debre Zeit Agricultural Research Centre. The result revealed that the highest increased income showed in Lume districts (positive net change in benefits) 37431.2 birr ha-1 followed by Siyadebirenawayu districts which was 31131.73 birr ha-1. However, the increase income in Lemo and Lalye maychew were minima l9513.34 birr ha-1 and 11469.95 birr ha-1 respectively. The benefit cost ratio for Lume and Siyadebir enawayu districts were 3.9 and 3.3. However, benefit cost ratio for Lemo and Lalye Machew were 1.7 and 1.9

The variables significantly affect the adoption of tef improved practices by farmers are age, education level, family size, farm size, extension service provision. To solve problems of inadequate use of improved practices, Development Agents and Agricultural experts should provide farmers with more practical trainings under farmers' direct participation in the demonstration centres. In order to attain food security, the nation policy makers should devise more effective farmers' training mechanisms and provide more applicable tef production mechanizations effective on the process of tef production.

Keywords: Economic, Agricultural, productivity, Technology

Introduction

Background

Among cereals, tef (Eragrostis tef) is indigenous to Ethiopia which is its centre of both origin and diversity. Tef is number one in terms of acreage allocated to its cultivation. It is grown by about 7 million smallholder farmers on over three million hectares of land, which is equivalent to 30% of the total area allocated to cereals (CSA, 2018). The wide-scale cultivation of tef is related to its tolerance to diverse environmental constraints including both excess (waterlogging) and scarce (drought) soil moisture. In addition to being nutritious, tef grains are free of gluten, causal agent for celiac disease; and hence tef is becoming globally popular as a life-style crop. It is a grain crop produced for human consumption almost solely in Ethiopia. It grows in most of the agro ecological zones of Ethiopia. The grain is an important crop used to make the Ethiopian staple food, injera, which is consumed at least once a day in better off households. Its straw, called chid, serves as a feed for livestock, and it is important raw material for the purpose of local house construction [1].

The Ethiopian government has developed the National Strategy document and designed to refocus national attention on tef and work towards doubling productivity in the next five years by identifying challenges, and proposing interventions to drive transformation of the tef value chain. The adoption of improved technologies for staple crop production is an important means to increase the productivity of smallholder agriculture so as to foster economic growth and improved well-being for millions of poor households. Without basic descriptive information, about who is adopting technologies and who is not, it is difficult to formulate policies for increasing agricultural productivity. Technology is often used broadly to encompass physical/biological structures or objects as well as management practices. Most often, researchers are interested in the adoption of specific technology components (e.g. fertilizer) or integrated technological packages (e.g. high yielding crop variety with fertilizer). However, it may be more important to study the character or functions and impacts of these

technologies. Since the role of the agricultural sector and its contribution to the Ethiopian economy is very immense, the success and failure of the Ethiopian economy is highly correlated to the performance of this sector. Nevertheless, the national average yield per unit area (at 1.75 tha-1) still remains low because quite large proportions of tef producing farmers not practicing improved practices like proper land preparation, recommended seed rate and variety, weed management, and recommended fertilizers and so on.

Digital Green is among Ethiopian Ministry of Agriculture's (MoA's) partners that have been working on improving agricultural production and productivity. Digital Green (DG) has been working on Video-Based Agricultural extension services approach to contribute to livelihood improvement of rural communities across the country. The aim of this organization (DG) is sharing improved agricultural practices with small-scale farmers through its video-based approach for effecting interpersonal behavioral change with small-scale farmers, and this overcomes challenges posed by illiteracy to increase production and productivity by enhancing technology uptake by farmers. Therefore, to realize the benefit of this video-based extension system, crop cut and household survey was conducted with the purpose of identifying the most improved practices of the project, and to measure changes in increasing the yields of tef, and thereby to see the production and income of smallholder farmers in some selected weredas in the major tef growing regions [2].

Overall Objective

The overall objective of the study was to identify the most adopted improved practices in terms of their greater contribution for better productivity and production towards improved livelihoods of tef producers and consumers, thereby, ensuring food security in Ethiopia.

Specific objectives

The specific objectives were as follows:

- To evaluate the effect of improved practices on yield, and identify those with greater marginal contribution to tef productivity / production;
- To identify barriers and triggers for adopting/not adopting recommended practices; and
- To have strong evidence for improved practices, share to relevant small-scale farmers and recommend this approach for scaling up, and influence agricultural extension policy making in the country.

Materials and Methods

Research Design

Both quantitative and qualitative methodologies (mixed approach) were used in order to assess the most adopted improved practices and different factors affecting the adoption level of improved practices on tef crop production between high-adopters and low-adopters in the process of tef production.

Types and sources of data

Crop cut and household surveys were conducted in in the four major tef growing regions of Ethiopia (Amhara, Oromia, South nations and nationality of people SNNP and Tigray) during the 2018/19 main season. One district in each of the regions of Oromia, SNNP and Tigray and Amhara Region were assessed (Table 1). The crop cut survey was employed using the CSA crop cut procedure with a slight modifications whereas the household survey was designed to solicit farm household level to assess the beneficiary perception, attitude, knowledge and feedbacks about video-based approach extension practice, to identify the most improved practice factors, and constraints that are hindering to adopt the technologies after watching the video-based extension services. Therefore, this study was based on both primary and secondary data which were generated using different data collection methods. Primary data were generated using rapid survey techniques involving key informant survey at different levels in the kebeles, and focus group discussion with tef growing farmers [2].

Sampling procedures

Target groups for this house hold (HH) survey were all households included in the crop cutting survey. Both the sample districts used for this study were determined by Digital Green before this survey study. Four major tef growing regions (Amhara, Oromia, Tigray and South Nations and Nationalities and People) were identified. From each regional state a sample of district classified on the basis of their modern technology usage were selected, and from these samples of peasant associations were identified using random sampling techniques. Therefore, simple random sampling techniques were employed to select ultimate sample units among smallholder farmers who were exposed to the intervention of the Digital Green during the 2018/19 Meher season. HH level survey was administered using CAPI through CSPro application.

In the first stage, one district from each region was selected and then three kebeles from each district were selected. Selection of districts was made based on the type of the crop they produce. In the second stage of sampling, 101 farm households from Amhara, Tigiray, SNN and 100 from Oromia districts were taken from the selected peasant associations on the basis of use of improved practices learnt from video-based extension service approach on tef production.

Methods of Data Collection

Field Observation

A structured survey questionnaire was adopted from the Ethiopian Rural Socioeconomic Survey (ERSS) crop cutting survey tool. Field observations and interviews were conducted. In addition data were collected on agro ecology, livestock, and farm.

Household Survey and Crop Cut

Structured interview with questions were used. Before the actual implementation of the survey enumerators were given training and evaluated for the clarity and reliability of the questions.

Focused Group Discussion Completion

FGD participants were chosen using stratified sampling to capture the views of the different category of farmers. FGD checklists were carefully prepared to capture all relevant information. A total of 403 farmers participated in focused group discussions in the four districts. Each of FGD was comprised 8 to 10 individual farmers. Of 403 farmers, 161 farmers were the so called 'model farmers. The participants in the FGD were composed of elders, young people and women.

Key Informant Interview (KII)

The KII were conducted with Digital Green staff, appropriate staffs from the Ministry of Agriculture and Livestock Resources (MoALR), regional BoANR, District Agriculture and Livestock Office Experts, and Development Agent (DAs) [3].

Methods of Data analysis and presentation

Both qualitative and quantitative methods were used in order to analyse collected data through questionnaires and focused group discussion. The quantitative data collected from the sample respondents were encoded in to SPSS (Statistical Package for Social Science) version 20.

Simple descriptive statistics such as percentage, mean, frequency and cross tabulation were used for analysis. In order to test significance difference among variables independent sample t test was used. Excel spread sheet was also used to analyse the qualitative data gathered through focused group discussion, key informant interviews and discussion held with DAs (development agents) were summarized to a manageable manner by grouping the same responses in to the same category. The major factors affecting the application of improved practices on tef cultivation in the study area were analysed.

Results and Discussion

From the survey data result 101 farmers in each districts of Amhara, SNNP and Tigray region and 100 farmers in Lume district of Oromia Region with a total of 403 farmers in four regions were interviewed. Detailed information on production, technology use, land and livestock resource, as well as on farming practices was collected through a structured questionnaire.

There could be several household and socio economic characteristics that affect the behaviour of a farmer. Identifying the factors affecting the adoption of a technology is an important exercise, which will have important policy implications. Thus, this analysis was undertaken with the aim of isolating the main factors that influence farmers' adoption behaviour. Technology adoption factors can be grouped into three broad categories 1), Demographic factors, 2) socio-economic factors, 3) agro ecological factors and 4) Institutional factors.

Adoption of Improved Practice

Data were analysed using SSPS. Among the seven improved practices assessed, fertilizer application, variety selection and use, land preparation and herbicide application showed higher adoption among the farmers.

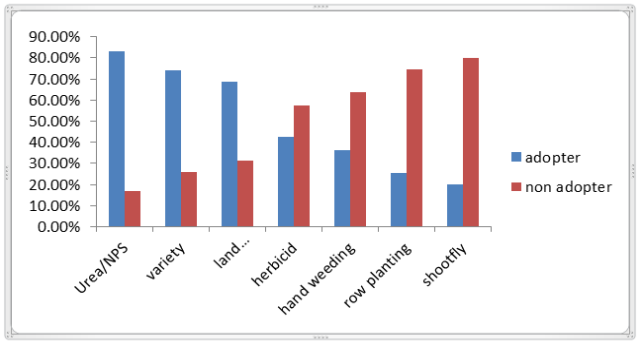

Figure 1: The Adoption of Improved practices in the study.

Grain yield by Districts

From the survey 101 sampled for each district were taken for Lelay-maychew, Lemo and Siyadebir-enawayu districts and 100 sampled for Lume district. The analysis of result showed that the highest grain were obtained from Lume which is 2210.80 kgha-1 followed by Siyadebir-nawayu districts1936.91 kgha-1 of both high potential areas. Result showed that there was significant difference among farmers with in districts and between districts. This indicates that the farmers were not adopting the improved practices being constant other factors like the agro ecology, rainfall and etc. Tef grain productivity and production partly and mainly depend on the use of improved practice applied Table 1.

Table 1: Table agronomic mean of grain yield obtained from survey sampled Districts.

District	Observation	Yield kg ha-1	Minimum	Maximum	t Value	Pr > |t|
Lelay-maichew	101	1082.05	350	2350	28.3	<.0001
Lemo	101	996.98	325	2750	24.74	<.0001
Lume	100	2210.8	1075	3007.5	56.24	<.0001
Siyadebir enawayu	101	1936.91	722.5	3425	39.36	<.0001
Source own survey data 2018/19						

Correlation of the improved practices with grain yield

Correlation analysis was performed to see the association of the improved practice with yield. The analysis result revealed that yield is positive and significant correlated with land preparation (r=0.492), row planting (r=0.351) hand weeding (0.306), fertilizer application(r=0.143) at different level of significance with yield. This implies that the uses of these IP were contributed for yield increment. Variety selection and application of herbicides were positive but not significant. This could be farmers did not select improved tef varieties and use based on the recommended agro ecology, and they did not practice application of herbicides appropriately. However, further intensive training should be given for tef producers to have good understanding and knowhow about the improved technologies in tef production to increase yield [3].

Economic analysis

Partial budget analysis

Partial budget analysis was employed to ensure that the tef production is desirable and economically sound. Thus, the technique of input-output analysis indicates the cost and benefit relationship of tef production technology as a basis for its proper evaluation and selection. The variable cost data were taken from Debre Zeit Agricultural Research Center collected from Ada District in 2018/19 for another study and used for all districts in this study to calculate the revenue and benefit cost ratio of grain yield in the study area. However, the straw value was not calculated for this study.

The result revealed that the highest increased income showed in Lume districts (positive net change in benefits) were 37431.2 birr ha-1 followed by Siyadebir enawayu which is 31131.73 birr ha-1 . However, the increase income in Lemo and Lalye maychew were minima l9513.34 birr ha-1 and 11469.95, respectively. Therefore, farmers should adopt improved practice to increase grain yield and their income

Factors Affect the Level of Adoption of Improved Practices

To identify the most impactful practices with greater marginal contribution to tef productivity /production it is very important to know factors that could potentially affect the level of adoption in tef production. Therefore, technology adoption factors can be grouped into four broad categories 1), Demographic factors, 2) socio-economic factors, 3) agro ecological factors and 4) institutional factors. Therefore, under each main category some of the factors are identified based on study of the survey data in selected districts of the study area.

House hold related factors

The Effect of Household Size on Adoption Rate of Tef Improved Practice

Land preparation: According to the data acquired from FGD most of the respondents suggested that the house hold size of the respondents significantly affects the respondents' adoptability to improved technologies. Since tef land preparation in the current situation is labour intensive method of production. Households with large family size were able to provide more number of labour assistance from the family members. From the result showed of farmers with large family size (>10) were 86.7 % high adopters for recommended land preparation. Farmers with 1-3 family size were the least adopters with 61.4 %. From this it can be concluded that household size had a positive effect on application of recommended land preparation. In the case of high-adopters household family size and level of adoption of land preparation is strongly and positively related [4].

Variety selection and use: As displayed in table 15, house hold size does not have effects on adoption of selection and use of improved tef varieties. Thus, variety selection and household size have no relationship

Row planting: As it is depicted on Table 15, in the case of high-adopters household family size and level of adoption of row planting practice is strongly and positively related. In the case of low-adopters household family size had a negative relationship with the application rate of row planting. This implies that in the current situation where there is no implanting machine, row planting needs high labour.

Application of fertilizer (the time it takes to apply): The result revealed that high adopter household size and level of adoption of application of fertilizer had a negative relationship with the application of fertilizer. It can conclude that the large household size the lesser time taken to apply fertilizer.

Hand weeding: even though they were few in number high adopters, large household size and the level of adoption of hand weeding had positive relationship. This indicates that hand weeding needs large family size. Herbicide application: the result did not show a relationship between household sizes with herbicide application. It implies that herbicide application does not depend on household size. The number of lower adopter of farmers was greater than higher adopter farmers.

Shootfly control from the table below the lower adopters was greater than the higher adopters. Household size did not show a relationship with shootfly control.

The Effect of Age Structure on Adoption Rate of Tef Improved Practices

Land preparation: The total respondents were youth for land preparation categorized in age group ranging between 20-40 years of age. The youth higher adopter exceeds the low adopter with in the same age group by 70.8%. Therefore, the majority of youth age group accepts improved practice for land preparation. Similarly the majority adult and older respondents were higher adopter accounts 64% and the lower adopters 82.2 % of the total respondent respectively in each age group. This implies that even though there were differences in adopting land preparation, all age groups categorized in this study accept improved land preparation practice.

Variety selection and use: in all age groups the higher adopter exceeds the low adopter for variety selection and use. Among youth respondents 75% were high adopters. Adult farmers' accounts about 73.5% were high adopters. Similarly older groups of high adopter were 63.9%. This implies that youth group are more active in variety selection and use than the other age groups.

Row planting: the result indicates that low-adopter of the respondent exceeds the high-adopters in each age group. Even though the high-adopters were lesser than the high adopters, among all the three age group, adult age groups were better adopter for row planting. Therefore, this implies that the youth and old age group did not adopt the application of row planting, this may be due to the youth and old age groups are poor and highly vulnerable to the risks of adopting row planting technology.

Fertilizer application: the youth and adult age group the high-adopters accounts 75% and 73.5% of the total respondent in each age group respectively exceed the low-adopters. Implies youth and adults are high adopters. However old age groups the low-adopter exceeds the high –adopter account by 73.4%. Therefore, youth and adult age group were high adopter this may be due to they are active learner than old age group.

Hand weeding: in all three age groups the low adopters exceed the high adopters for hand weeding. Therefore, it was not adopted in all age group this may be due to the fact hand weeding demands high labour. However in herbicide application in all age groups the higher adopters were exceed the low adopter. The result shows as age increase the adoption of herbicide increases this may be due to the fact that the older age group are weak.

Shoot fly control: in all age group the low adopter exceeds the high adopter. Even though the high adopters were lesser than low adopters, as the age increase the adoption of shootfly increase. This indicates that, may be due to understanding difference between the youth age and the old age considers the shoot fly has yield loss.

The Effect of Education on the Adoption Rate of Tef Improved Practices

Education and application level of improved farming activities were positively related. Educational status of a farmer may directly affect adoption and application of new agricultural technologies

Land preparation: A total of 403 sample respondents were categorized under the educational level of illiterate Among these 30 sample respondents educational grade were from grade 9-10 and they were high adopters with 93.3% of adoption rate; this implies that the level of adoption of land preparation is highly affected by the level of education, farmers with low educational attainment had low application level of new farming methods. As the local farmers' educational attainment level increases farmers' willingness to adopt land preparation practices at the same time increases.

Variety selection and use: farmers with low educational attainment had low variety selection and use adoption. From the result as the local farmers' educational attainment level increases, farmers' willingness to adopt improved variety at the same time increases.

Row planting: the result presented in table 5, similar to variety selection and use as farmers' education level increase the row planting practice increases this is the fact the farmers' willingness and understanding of the use of improved practice increases.

Fertilizer application: all most in all education level the respondent farmers are high adopter. Therefore, the result indicates that education level did not affect the fertilizer application this may be all educational level of farmers understand the use of fertilizer.

Hand weeding: from the result displayed in Table 5 there was no constant education level of effect of on hand weeding and similarly for herbicide application. This implies that weed management practice is not adopted in all educational level of the respondent.

Shoot fly control: as the education level increased adoption of shoot fly control decreased though at grade 11-12 increased (due to small respondent number). Therefore, this implies that the higher the education level they consider the loss yield due to shoot fly is minimal.

The effect of farm size on the adoption of improved practices

Land preparation: The result displayed in Table 6 revealed that the smaller the farm size is the high adopters by the respondent. Among the respondents the farm size < 1 were high adopters' accounts 72.5%. This indicates that smaller the farm size the better adoption for land preparation this may be due to tef land preparation needs high labour cost and take more time.

Variety selection and use: Respondents with farm size categorized < 1 and 1.1- 2 hectare were high adopters; however, respondent farmers with > 3 hectare farm size are low adopters. This is may be the fact that large farm size needs more seed and cost more seed price to use improved varieties.

Row planting: showed that the low adopters exceed the high adopters in all farm size categories. Even though the high adopters were lesser than the high adopter the smaller the farm size was the better adopter in the row planting practice. This implies that under current situation where there is no appropriate row planter, the row planting practice is time consuming and difficult to apply in large farm size.

Application of Fertilizer: the result illustrated in Table 6 respondents with the smaller farm size was the higher adopter of application of fertilizer. This is due to the fact that large farm size requires more fertilizer and costs more.

Hand weeding: respondent farmers with farm grouped under farm size > 3 hectare were the higher adopter this is may be due to the farmers with large farm size have more household size/labour.

Herbicide application: the result exhibited as the farm size increased the application of herbicide increased this is may be due to tef weeding is time consuming and labour demanding.

Shoot fly control: as opposed to herbicide application the smaller the farm size the higher adopter the shoot fly control this may be due to farmers with small farmer size fear the yield loss by shoot fly.

Institutional factors

Access to extension service

Extension services were very important and effective to enhance the productivity of tef grain in the study area. Based on the data gathered from DAs, they pointed out that they spent much of their working time on farmers' field.

They also frequently visited the working progress of farmers on the field and provide skill training and knowledge transfer. Beside all these farmers obtained free labour support on the application of improved practices from DAs. The result shows there were farmers who have easy extension accesses with high-adopters of improved practices [5].

Conceptual Framework on the Adoption of Improved Practices

Previous study indicated that agricultural growth in Sub Sahara Africa (SSA) is considered to be low. Ethiopia as part of SSA is struggling to improve its agricultural productivity through exposing farmers to new and modern grain production systems, and application of agricultural inputs.

Tef is the major grain in Ethiopia in terms of production area and level of consumption, though its productivity is very low this resulted in high price of the product in the Tef value chain and band tef export.

From this study farmers' adoption level of modern production system- Tef impactful practices were affected by the characteristics of four major categories of factors (Fig 2) like Age, level of education, household size, farm size, number of ox they have, access to extension service, level of training provided, use of technology, agro ecology. This intern affects the level of Technology adoption.

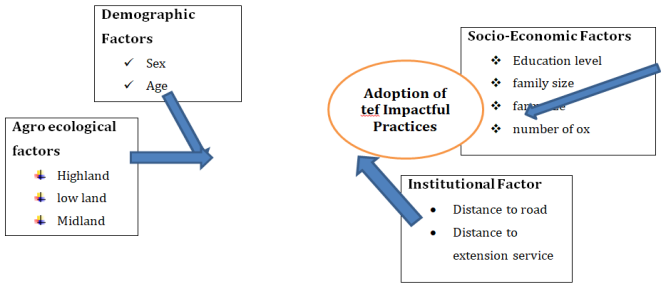

Figure 2: conceptual frame work on the adoption of improved practice.

Conclusion

Seven major tef production improved practices were identified for this survey study. Household survey and crop cut survey were used in four regions, one district in each region. Therefore, 101 farmer each in Amhara, SNNP, Tigray and 100 farmers in Oromia regions of Ethiopia were assessed in the study. The result of the current study showed that majority of the farmers in the study area did not adopt all improved tef practices. Among the seven improved practices assessed, fertilizer application, variety selection and use, land preparation and herbicide application showed relatively better adoption among the farmers. The most adopted improved practices impacting on yield and its correlation were identified. land preparation (r=0.492), row planting (r=0.351) hand weeding (0.306), fertilizer application (r=0.143).This implies that the adoptions of these improved practices were contributing to yield increment. Household size had a positive effect on application of recommended land preparation, row planting, application of fertilizer and hand weeding. However, it does not have positive correlation with variety selection, shootfly control and herbicide application. In the case of high-adopters household family size and level of adoption of land preparation is strongly and positively related From age group the result showed that youth were active in variety selection and use, land preparation and fertilizer application. Likewise, Adult group were adopted row planting and fertilizer application. In contrast, the application of herbicide increases when age increases. Education and application level of improved farming activities were positively related in most of the practices however, on application of herbicides and hand weeding there were no constant education effect. The result indicated that smaller the farm size the better adoption for land preparation, variety selection and use, row planting. Fertilizer application and shootfly control, this may be due to tef production needs high labour cost and take more time. On the other hand, the larger the farm sizes were the high adopter in hand weeding and herbicide application. In general, the result clearly indicated factors that affect the adoption of improved practices like demographic factors, socio economic factors and institutional factors. Benefit cost ratio for Lume and Siyadebir enawayu districts were 3.9 and 3.3. However benefit cost ratio for Lemo and Lalye Machew were 1.7 and 1.9.

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